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Effect of sowing dates and spacing on *Maruca vitrata* (Geyer) and *Helicoverpa armigera* (Hubner) in pigeonpea

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Abstract

The effect of sowing dates and spacing on *Maruca vitrata* (Geyer) and *Helicoverpa armigera* (Hubner) indicated that pigeonpea crop sowing during late in 2nd fortnight of August with more spacing (90 cm x 20 cm) recorded significantly the lowest *Maruca vitrata* (Geyer) and *H. armigera* population with 0.27 and 0.38 larva per plant, respectively.

Keywords: *Maruca vitrata*, *Helicoverpa armigera*, sowing date, spacing, pigeonpea

Introduction

Pigeonpea [*Cajanus cajan* (Linnaeus) Millspaugh] is an important grain legume crop of the tropics and sub-tropics. It is also known as tur, arhar and redgram. Pigeonpea is a rich source of protein (22.3%) which supplies a major share of the protein requirement of the vegetarian population of the country, making it a valuable component for improving food security and nutrition for many poor families (Tiwari and Shivhare, 2016) [10]. It has better quality of fiber, 7 g/100 g of seeds (Kandhare, 2014) [4]. Besides its nutritional value, it also possesses various medicinal properties due to the presence of a number of polyphenols and flavonoids. Pigeonpea is a multi-purpose crop used as dal (split grains), vegetable (green seeds and pods), fodder (green and dry leaves), feed (dry crushed grains) and fuel. It helps in natural nitrogen fixation and can be grown for green manuring. Globally, pigeonpea is grown in an area of 6.03 million hectares with a production of 5.33 million tonnes and productivity of 883.40 kg/ha (FAO, 2022) [1]. In India, it is grown on 5.05 million hectares with an annual production and productivity of 4.34 million tonnes and 859 kg/ha, respectively. Maximum economic damage is caused by the insect pests feeding on buds, flowers and pods. Among several insect pests infesting pigeonpea, the lepidopteran pests viz., pod borer, *Helicoverpa armigera* (Hubner); spotted pod borer, *Maruca vitrata* (Geyer); pod fly, *Melanagromyza obtusa* (Malloch); plume moth, *Exelastis atomosa* (Walshingham) and blue butterfly, *Lampides boeticus* (Linnaeus) are most serious. Damage inflicted by *H. armigera* larvae is confined to flowers, seeds and pods and a single larva can destroy 30-40 pods. Whereas *M. vitrata* larvae causes substantial damage to flowers by webbing and also boring into the pods (Sreekanth *et al.*, 2015) [9]. In India, the pod damage caused by *M. obtusa*, *C. gibbosa*, *H. armigera* and *M. vitrata* has been reported to be 34.4 to 49.9, 23.1 to 47.3, 9.4 to 18.1 and 5.7 to 12.4 per cent, respectively (Keval *et al.*, 2017) [6]. Considering the above facts, the present investigations are carried out.

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Materials and Methods

Experimental details:

Location	:	Agronomy Instructional Farm C. P. College of Agriculture S. D. Agricultural University Sardarkrushinagar
Year & Season	:	Kharif, 2021-22 and 2022-23
Crop and Variety	:	Pigeonpea, GT 101
Design	:	RBD (Factorial concept)
Replications	:	4
Treatments	:	8
Plot size i) Gross	:	5.40 m x 4.00 m
ii) Net	:	S ₁ - 4.20 m x 3.00 m S ₂ - 3.60 m x 3.00 m
Fertilizer	:	25:50:00 - N:P:K (kg/ha)
Details of treatments: First factor level	:	Date of sowing D ₁ - 1 st fortnight of July D ₂ - 2 nd fortnight of July D ₃ - 1 st fortnight of August D ₄ - 2 nd fortnight of August
Second factor level	:	Spacing S ₁ - 60 cm x 20 cm S ₂ - 90 cm x 20 cm
Treatments	:	T ₁ -D ₁ S ₁ , T ₂ -D ₁ S ₂ , T ₃ -D ₂ S ₁ , T ₄ -D ₂ S ₂ T ₅ -D ₃ S ₁ , T ₆ -D ₃ S ₂ , T ₇ -D ₄ S ₁ , T ₈ -D ₄ S ₂

Observations recorded

Five plants from each treatment were randomly tagged, and observations on the larval population of *Maruca vitrata* (Geyer) and *Helicoverpa armigera* (Hubner) in pigeonpea

were recorded at weekly interval from pest emergence to harvest. Simultaneously, natural enemies were also be recorded.

Results and Discussion

A field experiment was conducted at the Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, during Kharif, 2021-22 and 2022-23 to investigate the influence of sowing dates and spacing on the *M. vitrata* and *H. armigera* in pigeonpea.

Spotted pod borer, *Maruca vitrata* (Geyer)

The pooled (Year 2021-22 and 2022-23) results are presented in Table 1 and graphically depicted in Fig. 1. The number of *M. vitrata* larvae per plant varied in different sowing dates. The results showed that a significantly lower (0.42 larva/plant) population was detected in late sown pigeonpea D₄ (2nd fortnight of August) which remained at par with D₃-1st fortnight of August (0.50 larva/plant). Significantly higher (2.09 larvae/plant) population was recorded when the crop sown early D₁ (1st fortnight of July) which was followed by D₂-2nd fortnight of July (1.01 larvae/plant). The mean larval population in all treatments was arranged in descending order: D₁ > D₂ > D₃ ≥ D₄.

Similar to sowing date, spacing was substantial effect on *M. vitrata* incidence. Larger spacing S₂ (90 cm x 20 cm) recorded significantly lower (0.78 larva/plant) population of *M. vitrata* compared to smaller spacing S₁-60 cm x 20 cm (1.09 larvae/plant).

Table 1: Effect of sowing dates and spacing on larval population of *Maruca vitrata* and *Helicoverpa armigera* infesting pigeonpea

Factor	Treatments	<i>Maruca vitrata</i> /plant			<i>Helicoverpa armigera</i> /plant		
		Year		Pooled over year	Year		Pooled over year
		2021-22	2022-23		2021-22	2022-23	
1. Sowing date (D)	D ₁	1.80 ^c (2.74)	1.42 ^c (1.52)	1.61 ^c (2.09)	1.74 ^d (2.53)	1.62 ^d (2.12)	1.68 ^d (2.32)
	D ₂	1.29 ^b (1.16)	1.17 ^b (0.87)	1.23 ^b (1.01)	1.46 ^c (1.63)	1.38 ^c (1.40)	1.42 ^c (1.52)
	D ₃	1.04 ^a (0.58)	0.97 ^a (0.44)	1.00 ^a (0.50)	1.24 ^b (1.04)	1.15 ^b (0.82)	1.20 ^b (0.94)
	D ₄	1.01 ^a (0.52)	0.90 ^a (0.31)	0.96 ^a (0.42)	1.02 ^a (0.54)	0.92 ^a (0.35)	0.97 ^a (0.44)
	S. Em. ±	0.04	0.04	0.07	0.05	0.05	0.04
2. Spacing (S)	C. D. at 5%	0.13	0.12	0.08	0.14	0.16	0.10
	S ₁	1.37 ^b (1.38)	1.17 ^b (0.87)	1.26 ^b (1.09)	1.44 ^b (1.57)	1.33 ^b (1.27)	1.38 ^b (1.40)
	S ₂	1.20 ^a (0.94)	1.07 ^a (0.64)	1.13 ^a (0.78)	1.29 ^a (1.16)	1.21 ^a (0.96)	1.25 ^a (1.06)
	S. Em. ±	0.03	0.03	0.02	0.03	0.04	0.03
Interaction D×S	C. D. at 5%	0.09	0.09	0.06	0.10	0.11	0.07
	S. Em. ±	0.06	0.06	0.04	0.07	0.08	0.05
	C. D. at 5%	0.18	0.18	0.12	0.20	0.22	0.15
	C. V. (%)	9.58	10.69	10.10	10.18	11.98	11.06

Figures in parentheses are retransformed values of $\sqrt{X} + 0.5$ transformed values

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance

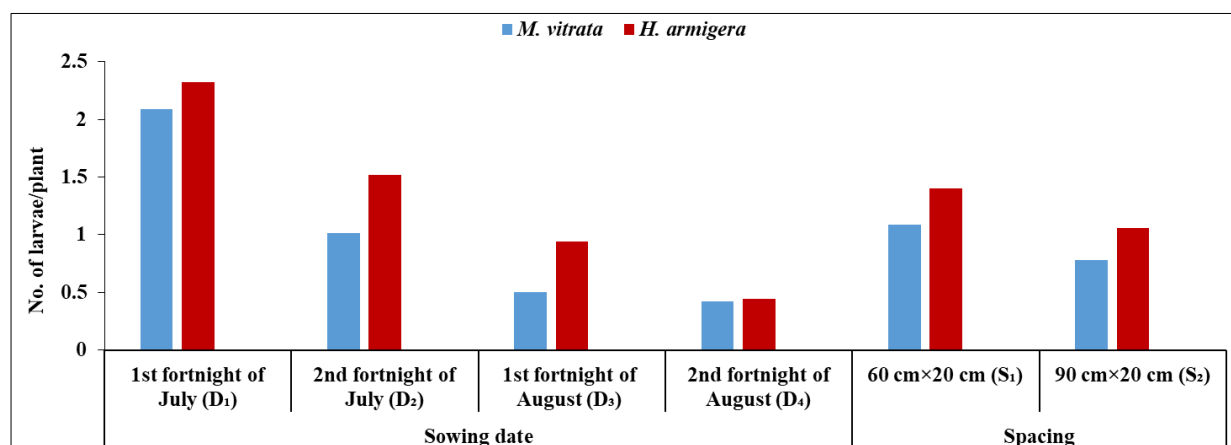


Fig 1: Effect of sowing dates and spacing on larval population of *Maruca vitrata* and *Helicoverpa armigera* infesting pigeonpea (Pooled)

Interaction effect of sowing dates and spacing of pigeonpea on incidence of *Maruca vitrata* (Geyer)

The pooled (Year 2021-22 and 2022-23) results are presented in Table 2 and graphically depicted in Fig. 2. The results showed the interaction impact of sowing date and spacing on *M. vitrata* incidence was significant. Among the treatment combinations of sowing date and spacing, data indicated that sowing of pigeonpea during D₄ (2nd fortnight of August) with S₂ (90 cm x 20 cm) spacing recorded

significantly minimum (0.27 larva/plant) population which remained at par (0.35 larva/plant) with D₃ (1st fortnight of August) with S₂ (90 cm x 20 cm) spacing. Whereas, the highest (2.53 larvae/plant) *M. vitrata* incidence was observed in D₁ (1st fortnight of July) sown pigeonpea with S₁ (60 cm x 20 cm) spacing which was preceded by D₁ (1st fortnight of July) sown pigeonpea with S₂-90 cm x 20 cm spacing (1.69 larvae/plant).

Table 2: Interaction effect of sowing dates and spacing on larval population of *Maruca vitrata* and *Helicoverpa armigera* infesting pigeonpea

Date of sowing	Spacing	<i>Maruca vitrata</i> /plant			<i>Helicoverpa armigera</i> /plant		
		Year		Pooled over year	Year		Pooled over year
		2021-22	2022-23		2021-22	2022-23	
D ₁	S ₁	1.90 ^d (3.11)	1.59 ^d (2.03)	1.74 ^e (2.53)	1.92 ^c (3.19)	1.81 ^e (2.78)	1.86 ^e (2.96)
	S ₂	1.70 ^c (2.39)	1.26 ^c (1.09)	1.48 ^d (1.69)	1.56 ^b (1.93)	1.43 ^d (1.54)	1.49 ^d (1.72)
D ₂	S ₁	1.27 ^b (1.11)	1.16 ^{bc} (0.85)	1.21 ^c (0.96)	1.44 ^b (1.57)	1.35 ^{cd} (1.32)	1.40 ^{cd} (1.46)
	S ₂	1.31 ^b (1.22)	1.18 ^{bc} (0.89)	1.25 ^c (1.06)	1.47 ^b (1.66)	1.41 ^d (1.49)	1.44 ^d (1.57)
D ₃	S ₁	1.15 ^b (0.82)	1.02 ^{ab} (0.54)	1.09 ^b (0.69)	1.35 ^b (1.32)	1.19 ^{bcd} (0.92)	1.27 ^c (1.11)
	S ₂	0.92 ^a (0.35)	0.93 ^a (0.36)	0.92 ^a (0.35)	1.13 ^a (0.78)	1.12 ^{abc} (0.75)	1.12 ^b (0.75)
D ₄	S ₁	1.16 ^b (0.85)	0.91 ^a (0.33)	1.04 ^b (0.58)	1.05 ^a (0.60)	0.95 ^{ab} (0.40)	1.00 ^{ab} (0.50)
	S ₂	0.86 ^a (0.24)	0.90 ^a (0.31)	0.88 ^a (0.27)	0.99 ^a (0.48)	0.90 ^a (0.31)	0.94 ^a (0.38)
S. Em. ±	D×S	0.06	0.06	0.04	0.07	0.08	0.05
	Y×D×S	-	-	0.06	-	-	0.07
C. D. at 5%	D×S	0.18	0.18	0.12	0.20	0.22	0.15
	Y×D×S	-	-	NS	-	-	NS
C.V. (%)		9.58	10.69	10.10	10.18	11.98	11.06

Figures in parentheses are retransformed values of $\sqrt{X + 0.5}$ transformed values

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance

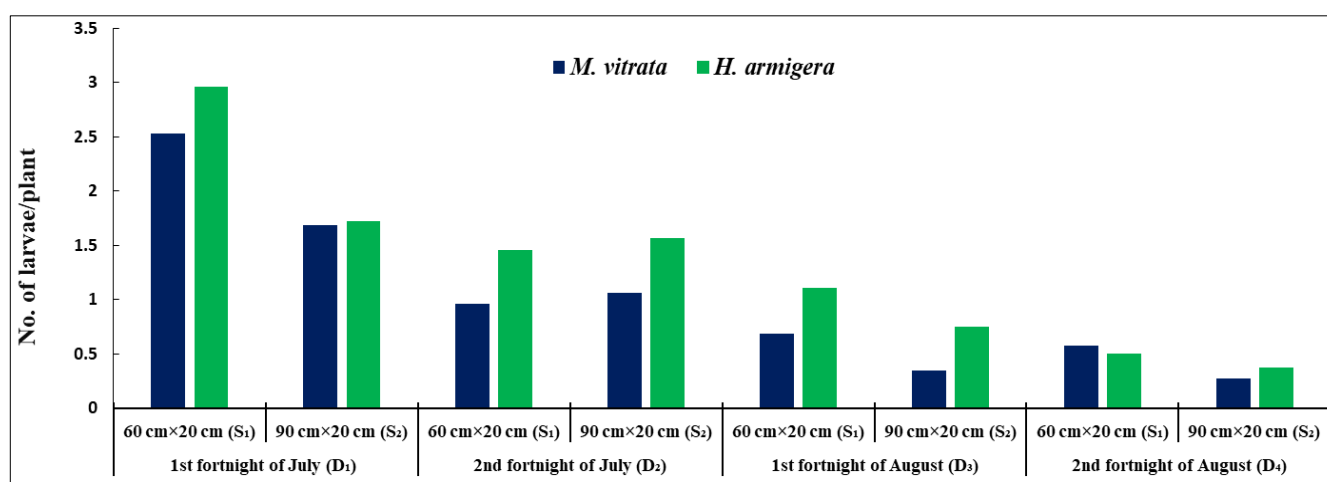


Fig 2: Interaction effect of sowing dates and spacing on larval population of *Maruca vitrata* and *Helicoverpa armigera* infesting pigeonpea (Pooled)

The above results clearly show that the late sown pigeonpea with greater spacing had a lower infestation with *M. vitrata*. In past, Kavitha and Vijayaraghavan (2020) also revealed that *M. vitrata* incidence was less in the 2nd fortnight of August sown pigeonpea crop. As a result, the current study is relatively consistent with earlier researcher.

Pod borer, *Helicoverpa armigera* (Hubner)

The pooled (Year 2021-22 and 2022-23) outcome on the incidence of *H. armigera* larvae varied substantially among sowing dates, as shown in Table 1 and graphically depicted in Fig 1. The results indicated that a significantly lower (0.44 larva/plant) larval population was recorded in late sown pigeonpea D₄ (2nd fortnight of August) which was

followed by D₃ (1st fortnight of August), D₂ (2nd fortnight of July) and D₁ (1st fortnight of July) with 0.94, 1.52 and 2.32 larvae per plant, respectively. The crop sown early D₁ (1st fortnight of July) was recorded higher larval population (2.32 larvae/plant). The mean larval population in all treatments was arranged in descending order: D₁ > D₂ > D₃ > D₄. The conclusions indicated that late sowing resulted in a lower incidence of *H. armigera*.

Similar to sowing date, spacing played significant effect on population of *H. armigera*. Among the investigated spacings, larger spacing S₂ (90 cm x 20 cm) recorded significantly lower (1.06 larva/plant) population of *H. armigera* than to smaller spacing S₁-60 cm x 20 cm (1.40 larvae/plant). The findings thus, proved that the occurrence of *H. armigera* was lowest at greater distances apart.

Interaction effect of sowing dates and spacing of pigeonpea on incidence of *Helicoverpa armigera* (Hubner)

Table 2 presents the pooled (Year 2021-22 and 2022-23) results, which is graphically depicted in Fig. 2. The results showed the interaction impact of sowing date and spacing on *H. armigera* incidence was significant. Among the treatments combination of sowing date and spacing indicated that late sowing of pigeonpea during D₄ (2nd fortnight of August) with S₂ (90 cm x 20 cm) spacing recorded significantly lower (0.38 larva/plant) population which remained at par with D₄ (2nd fortnight of August) with

S₁ (60 cm x 20 cm) spacing (0.50 larva/plant). Whereas, significantly higher (2.96 larvae/plant) *H. armigera* incidence was observed in D₁ (1st fortnight of July) sown pigeonpea with S₁ (60 cm x 20 cm) spacing.

The above results clearly suggest that late-sown pigeonpea with larger spacing had a lower infestation of *H. armigera*. In past, Patel *et al.* (2019) [7] at Anand reported that early sown crop suffers higher population of *H. armigera*. Hadiya *et al.* (2020) at Panchmahals also revealed that late sown (31st and 33rd SMW) pigeonpea crop had significantly lower population of *H. armigera*, which was concurrent with the present study.

Natural enemies

Spider

The pooled (Year 2021-22 and 2022-23) outcome on spider varied substantially among sowing dates, as shown in Table 3. The results showed significantly lower population (0.46 spider/plant) in late-sown pigeonpea D₄ (2nd fortnight of August). Whereas the higher spider population (1.66 spiders/plant) was recorded when the crop was sown during D₂-2nd fortnight of July.

Among the different tested spacings, the S₂-90 cm x 20 cm spacing recorded the significantly lowest (0.89 spider/plant) population than S₁-60 cm x 20 cm spacing (1.14 spiders/plant). The study discovered that increasing spacings resulted in the lowest population of spiders.

Table 3: Effect of sowing dates and spacing on incidence of natural enemies in pigeonpea

Factor	Treatments	Spider/plant			Lady bird beetle/plant		
		Year		Pooled over year	Year		Pooled over year
		2021-22	2022-23		2021-22	2022-23	
1.Sowing date (D)	D ₁	1.29 ^b (1.16)	1.31 ^c (1.22)	1.30 ^c (1.19)	1.09 ^a (0.69)	1.15 ^a (0.82)	1.12 ^b (0.75)
	D ₂	1.51 ^c (1.78)	1.44 ^c (1.57)	1.47 ^d (1.66)	1.23 ^b (1.01)	1.28 ^b (1.14)	1.25 ^c (1.06)
	D ₃	1.21 ^b (0.96)	1.11 ^b (0.73)	1.16 ^b (0.85)	1.07 ^a (0.64)	1.13 ^a (0.78)	1.10 ^a (0.71)
	D ₄	1.00 ^a (0.50)	0.96 ^a (0.42)	0.98 ^a (0.46)	1.02 ^a (0.54)	1.04 ^a (0.58)	1.03 ^a (0.56)
	S. Em. ±	0.05	0.04	0.03	0.04	0.04	0.03
	C. D. at 5%	0.15	0.13	0.10	0.12	0.12	0.08
2. Spacing (S)	S ₁	1.31 ^b (1.22)	1.25 ^b (1.06)	1.28 ^b (1.14)	1.15 ^b (0.82)	1.19 ^b (0.92)	1.17 ^b (0.87)
	S ₂	1.19 ^a (0.92)	1.16 ^a (0.85)	1.18 ^a (0.89)	1.06 ^a (0.62)	1.10 ^a (0.71)	1.08 ^a (0.67)
	S. Em. ±	0.04	0.03	0.02	0.03	0.03	0.02
	C. D. at 5%	0.10	0.09	0.07	0.08	0.08	0.06
Interaction (D×S)	S. Em. ±	0.07	0.06	0.05	0.06	0.06	0.04
	C. D. at 5%	NS	NS	NS	NS	NS	NS
	C. V. (%)	11.36	10.22	10.83	10.39	9.96	10.17

Figures in parentheses are retransformed values of $\sqrt{X + 0.5}$ transformed values

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance.

Interaction effect of sowing dates and spacing on spider

The pooled (Year 2021-22 and 2022-23) results (Table 4) of interaction between sowing date and spacing on spider population was non-significant. Among the treatment combinations of sowing dates and spacing, sowing of pigeonpea during D₄ (2nd fortnight of August) with S₂ (90

cm x 20 cm) spacing resulted in a lower (0.33 spider/plant) spider population. Whereas, the highest population was found in D₂ (2nd fortnight of July) with S₁-60 cm x 20 cm spacing (1.87 spiders/plant). The results above indicated that early sowing with closer spacing resulted in a higher population of spiders.

Table 4: Interaction effect of sowing dates and spacing on incidence of natural enemies in pigeonpea

Date of sowing	Spacing	Spider/plant			Lady bird beetle/plant		
		Year		Pooled over year	Year		Pooled over year
		2021-22	2022-23		2021-22	2022-23	
D ₁	S ₁	1.41 (1.49)	1.30 (1.19)	1.35 (1.32)	1.11 (0.73)	1.14 (0.80)	1.12 (0.75)
	S ₂	1.17 (0.87)	1.32 (1.24)	1.25 (1.06)	1.08 (0.67)	1.16 (0.85)	1.12 (0.75)
D ₂	S ₁	1.59 (2.03)	1.49 (1.72)	1.54 (1.87)	1.24 (1.04)	1.32 (1.24)	1.28 (1.14)
	S ₂	1.44 (1.57)	1.38 (1.40)	1.41 (1.49)	1.22 (0.99)	1.23 (1.01)	1.23 (1.01)
D ₃	S ₁	1.19 (0.92)	1.16 (0.85)	1.18 (0.89)	1.15 (0.82)	1.17 (0.87)	1.16 (0.85)
	S ₂	1.23 (1.01)	1.06 (0.62)	1.14 (0.80)	0.99 (0.48)	1.09 (0.69)	1.04 (0.58)
D ₄	S ₁	1.06 (0.62)	1.05 (0.60)	1.05 (0.60)	1.08 (0.67)	1.15 (0.82)	1.11 (0.73)
	S ₂	0.94 (0.38)	0.88 (0.27)	0.91 (0.33)	0.95 (0.40)	0.92 (0.35)	0.94 (0.38)
S. Em. ±	D×S	0.07	0.06	0.05	0.06	0.06	0.04
	Y×D×S	-	-	0.07	-	-	0.06
C. D. at 5%	D×S	NS	NS	NS	NS	NS	NS
	Y×D×S	-	-	NS	-	-	NS
C. V. (%)		11.36	10.22	10.83	10.39	9.96	10.17

Figures in parentheses are retransformed values of $\sqrt{X} + 0.5$ transformed values

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance.

Lady bird beetle

The pooled (Year 2021-22 and 2022-23) outcome on lady bird beetle varied substantially among sowing dates, as shown in Table 3. The results showed that a significantly the lowest (0.56 lady bird beetle/plant) population was recorded in late-sown pigeonpea D₄ (2nd fortnight of August) which remained at par with D₃ (1st fortnight of August) with 0.71 lady bird beetle per plant. Whereas the maximum (1.06 lady bird beetles per plant) population was recorded when the crop was sown during D₂ (2nd fortnight of July).

Similar to sowing date, spacing had a substantial effect on lady bird beetle incidence. Among the tested spacings, S₂ (90 cm x 20 cm) spacing observed the lowest number of lady bird beetle (0.67/plant) than S₁ (60 cm x 20 cm) spacing (0.87 lady bird beetle/plant).

Interaction effect of sowing dates and spacing on lady bird beetle

The pooled (Year 2021-22 and 2022-23) results are presented in Table 4. The results showed the interaction effect of sowing date and spacing on lady bird beetle was found non significant. Among the treatment combinations of sowing dates and spacing, data indicated that sowing of pigeonpea during the D₄ (2nd fortnight of August) with S₂ (90 cm x 20 cm) spacing resulted in a lower population (0.38 lady bird beetle/plant). Whereas, the maximum incidence was found in D₂ (2nd fortnight of July) with S₁ (60 cm x 20 cm) spacing (1.14 lady bird beetle/plant).

The results above indicated that early sowing with less spacing resulted in a high population of lady bird beetles.

In the past, Patel (2016) [8] at Navsari reported highest number of spider (1.04 spiders/plant) in the crop sown on 2nd fortnight of July. While, lower spider population was recorded in crop sown on 2nd fortnight of August. As a result, the current study's conclusions are broadly consistent with those of earlier researchers.

Seed Yield

The pooled (Year 2021-22 and 2022-23) data showed the effect of sowing dates and varieties on yield (Table 5 and Fig. 3). The data showed that the crop sown early in the D₁ (1st fortnight of July) had a significantly higher (908 kg/ha) yield. Pigeonpea seeded on the D₂ (2nd fortnight of July) produced 821 kg/ha yield, while significantly lowest (559 kg/ha) yield was observed in the D₄ (2nd fortnight of August) but remained comparable to D₃-2nd fortnight of August (696 kg/ha).

Spacing exhibited significant effect on yield of pigeonpea. Lesser spacing S₁ (60 cm x 20 cm) was recorded significantly maximum (828 kg/ha) yield than higher spacing S₂-90 cm x 20 cm (664 kg/ha).

Table 5: Effect of sowing dates and spacing on seed yield of pigeonpea

Factor	Treatments	Seed yield (kg/ha)		
		Year		Pooled over year
		2021-22	2022-23	
1. Sowing date (D)	D ₁	831 ^d	986 ^d	908 ^d
	D ₂	737 ^c	905 ^c	821 ^c
	D ₃	650 ^b	742 ^b	696 ^b
	D ₄	528 ^a	591 ^a	559 ^a
	S. Em. ±	24.76	25.77	17.87
	C. D. at 5%	72.82	75.78	51.00
2. Spacing (S)	S ₁	771 ^b	885 ^b	828 ^b
	S ₂	602 ^a	727 ^a	664 ^a
	S. Em. ±	17.51	18.22	12.63
	C. D. at 5%	51.49	53.58	36.06
Interaction (D×S)	S. Em. ±	35.02	36.44	25.27
	C. D. at 5%	102.98	107.17	72.11
	C. V. (%)	10.20	9.04	9.58

Treatment means with the letter(s) in common are not significantly different by DNMRT at 5% level of significance

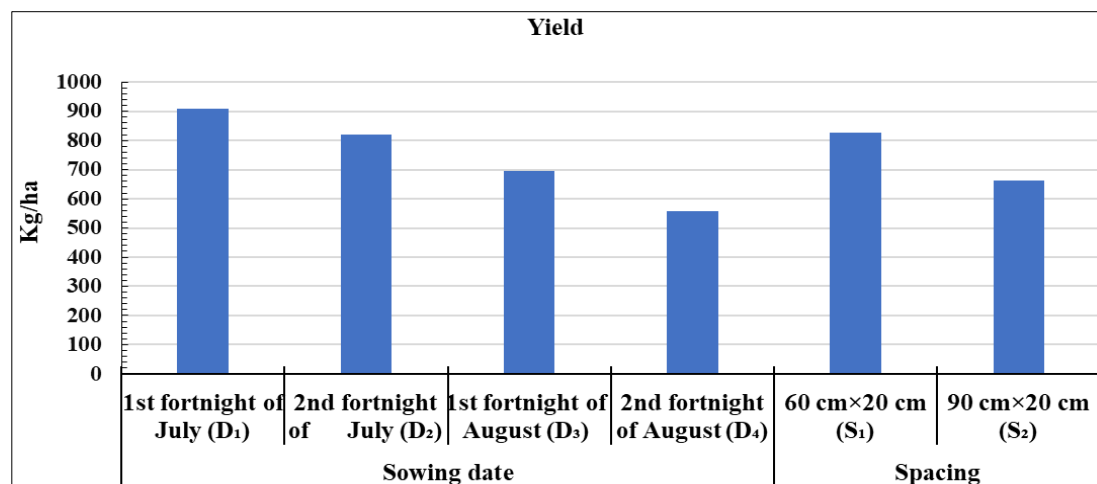


Fig 3: Effect of sowing dates and spacings on seed yield of pigeonpea (Pooled)

Interaction effect of sowing dates and spacing on seed yield

Table 6 presents the pooled results, which are graphically depicted in Fig. 4. The results showed the interaction impact of sowing date and spacing on yield was significant. Among the treatment combinations of sowing date and spacing, sowing of pigeonpea during the D₁ (1st fortnight of July) seeded pigeonpea with S₁ (60 cm x 20 cm) spacing recorded significantly highest (1008 kg/ha) yield followed by D₂ (2nd fortnight of July) with S₁ (60 cm x 20 cm) spacing (900 kg/ha). Whereas, the pigeonpea was sown late D₄ (2nd fortnight of August) with S₂ (90 cm x 20 cm) spacing resulted in a significantly lowest yield with 534 kg per ha. The results above indicated that pigeonpea sown early with lower spacing resulted in a maximum production of yield.

In the past, Ghetiya (2010) [2] at Anand reported that the maximum loss can be avoided in 1st week of July sown pigeonpea due to reduction in different pests infesting pigeonpea with higher yield. Patel (2016) [8] at Navsari reported that 1st fortnight of July sown crop recorded significantly higher grain yield (1219 kg/ha) as compared to subsequent sowings, while the lowest yield was noticed in August 2nd fortnight sowing (747 kg/ha). Dobhal *et al.* (2018) at Pantnagar reported that 10th June sowing dates recorded significantly higher yield (1219 kg/ha) as compared to subsequent sowing, while the lowest yield (747

kg/ha) was noticed in crop sown on 10th August. As a result, the current study's conclusions are broadly consistent with those of earlier researchers.

Table 6: Interaction effect of sowing dates and spacing on seed yield of pigeonpea

Date of sowing	Spacing	Seed yield (kg/ha)		
		Year		Pooled over year
		2021-22	2022-23	
D ₁	S ₁	945 ^a	1072 ^a	1008 ^a
	S ₂	718 ^{bc}	900 ^{bc}	809 ^{cd}
D ₂	S ₁	796 ^b	1004 ^{ab}	900 ^b
	S ₂	679 ^c	806 ^c	742 ^d
D ₃	S ₁	779 ^{bc}	859 ^c	819 ^c
	S ₂	522 ^d	626 ^d	574 ^e
D ₄	S ₁	565 ^d	605 ^d	585 ^e
	S ₂	490 ^d	577 ^d	534 ^e
S. Em. ±	D×S	35.02	36.44	25.27
	Y×D×S	-	-	35.74
C. D. @ 5%	D×S	102.98	107.17	72.11
	Y×D×S	-	-	NS
C. V. %		10.20	9.04	9.58

Treatment means with the letter(s) in common are not significantly different by DNMRD at 5% level of significance

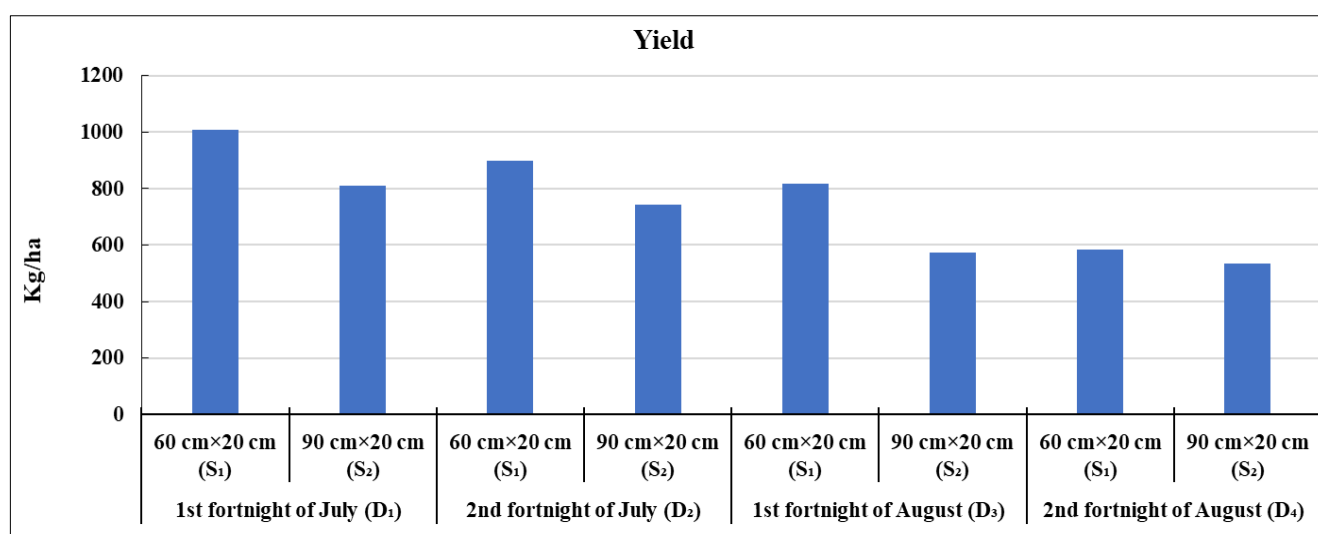


Fig 4: Interaction effect of sowing dates and spacings on seed yield of pigeonpea (Pooled)

Conclusion

Spotted pod borer, *Maruca vitrata* (Geyer)

The significantly lowest (0.42 larva/plant) population was detected in the late sown pigeonpea during 2nd fortnight of August and significantly higher (2.09 larvae/plant) population was recorded when the crop was sown during early i.e., 1st fortnight of July. Among the tested spacings, larger spacing of 90 cm x 20 cm recorded significantly the lowest (0.78 larva/plant) population of *M. vitrata* as compared to smaller spacing of 60 cm x 20 cm (1.09 larvae/plant).

Interaction impact of sowing dates and spacing on *M. vitrata* incidence were found significant. Late sowing of pigeonpea during 2nd fortnight of August with more 90 cm x 20 cm spacing recorded significantly minimum (0.27 larva/plant) population, whereas, significantly the highest (2.53 larvae/plant) incidence of *M. vitrata* was observed in 1st fortnight of July with 60 cm x 20 cm spacing.

Pod borer, *Helicoverpa armigera* (Hubner)

The results showed that significantly lower (0.44 larva/plant) population was recorded in the late sown pigeonpea during 2nd fortnight of August. The crop sown early during 1st fortnight of July recorded significantly higher population (2.32 larvae/plant). Among the investigated spacings, 90 cm x 20 cm spacing recorded significantly lower (1.06 larva/plant) population of *H. armigera* as compared to 60 cm x 20 cm spacing (1.40 larvae/plant).

The interaction impact of sowing dates and spacing on *H. armigera* incidence was significant. The results indicated that late sowing of pigeonpea during 2nd fortnight of August with 90 cm x 20 cm spacing recorded significantly lower (0.38 larva/plant) population. Whereas, significantly highest (2.96 larvae/plant) *H. armigera* incidence was observed in 1st fortnight of July with 60 cm x 20 cm spacing.

Natural enemies

Spider

Significantly lower (0.46 spider/plant) population of spider was observed in late sown pigeonpea during 2nd fortnight of August. Whereas the higher (1.66 spiders/plant) spider population was recorded when the crop was sown during 2nd fortnight of July. The 90 cm x 20 cm spacing recorded significantly lowest (0.89 spider/plant) population than 60 cm x 20 cm spacing (1.14 spiders/plant).

Interaction between sowing dates and spacing on spider population was non-significant. Pigeonpea crop sown during 2nd fortnight of August with 90 cm x 20 cm spacing resulted in significantly lower (0.33 spider/plant) spider population. Whereas, the significantly highest (1.87 spiders/plant) population was found in 2nd fortnight of July with 60 cm x 20 cm spacing.

Lady bird beetle

The results revealed that significantly lowest (0.56 lady bird beetle/plant) population was recorded in late 2nd fortnight of August sown pigeonpea which remained at par with 1st fortnight of August with 0.71 lady bird beetle per plant. Whereas, significantly maximum (1.06 lady bird beetles/plant) population was recorded when the crop was sown during 2nd fortnight of July. Among the tested spacing, 90 cm x 20 cm spacing observed the lowest number of lady

bird beetle (0.67/plant) than 60 cm x 20 cm spacing (0.87 lady bird beetle/plant).

The results showed the interaction impact of sowing dates and spacing on lady bird beetle as non-significant. Sowing of pigeonpea during 2nd fortnight of August with 90 cm x 20 cm spacing resulted in a lower (0.38 lady bird beetle/plant) population. Whereas, the maximum incidence was found in 2nd fortnight of July with 60 cm x 20 cm spacing (1.14 lady bird beetle/plant).

Seed yield

The data showed that the pigeonpea sown early 1st fortnight of July obtained significantly higher (908 kg/ha) yield while significantly lowest (559 kg/ha) yield was observed in the 2nd fortnight of August. Spacing with 60 cm x 20 cm recorded the maximum (828 kg/ha) yield better than 90 cm x 20 cm (664 kg/ha).

Significant effect was observed when the interaction of sowing dates and spacing on yield was studied. The data revealed that sowing of pigeonpea during early 1st fortnight of July with smaller spacing (60 cm x 20 cm) spacing recorded significantly the highest (1008 kg/ha) seed yield. Whereas, the pigeonpea sown late (2nd fortnight of August) with 90 cm x 20 cm spacing resulted in a significantly lowest yield with 534 kg per ha.

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